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ABSTRACT

Great attention is being paid to the current high definition television (HDTV) system proposals that are being examined by the Federal Communications Commission Advisory Committee, and due to be tested over the next few years by the Advanced Television Test Center and by Cable Television Laboratories. Arguing that the focus of this activity has tended to mask some of the factors which may prove more pivotal to the successful establishment of HDTV in the United States, this paper discusses some of the factors that seem to be fundamental to the success of HDTV, poses questions, and identifies issues of concern to broadcasters and to operators of cable television systems. A review of basic spectrum architectures of the systems currently proposed is followed by discussions of related consumer issues, standards, and costs for producers, distributors, and viewers. (GL)

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High Definition Television: Factors Critical To Success

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The subject of High Definition Television has many facets. It is being discussed, in its most obvious context, as the future of home entertainment. It is also seen by some as a key to the resuscitation of the U.S. consumer electronics industry; as an element in the solution to the U.S. trade deficit, and as a model of successful Japanese techniques in technology development and manufacturing. It is seen as a merging point for computer technologies and the television screen, and as a classic exercise in determining the highest and best use of our electromagnetic spectrum. Some characterize it as an economic engine for implementing fiber optics to the home, and even as an important future tool in U.S. defense capabilities.

It may well be, though, that the significance of HDTV in these related areas depends upon the fundamental commercial success of high definition television in the home -- a success which is not at all clear or certain. Without a wide base of mass programming services in high definition video, and the related high volume, low-unit-cost manufacturing business, the scale of industrial involvement could remain small, limiting the advancement of the technology and its expansion into other applications.

Great attention is being paid, and rightfully so, to the current advanced television system proposals being examined by the FCC Advisory Committee, and due to be tested over the next few years

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by the Advanced Television Test Center and by Cable Television Laboratories. However, the focus on this activity has tended to mask some of the factors that may prove more pivotal to the successful establishment of high definition services in the United States.

This paper will discuss some of the factors that appear to be fundamental to the success of this new medium, and in the process, will pose some questions and identify some issues of concern to broadcasters and to operators of cable television systems.

First, a review of the basic spectrum architectures of the systems currently proposed will provide a framework for thought on the entire subject.

A Review of the Approaches

Three basic channelization approaches are currently being pursued by the organizations with system proposals before the FCC Advisory Committee on Advanced Television Service:

• One option proposed is a single, 6 MHz NTSC channel with some added high definition information that is invisible to, and therefore compatible with, existing NTSC receivers. Those NTSC receivers would display their traditional 525-line pictures when tuned to an advanced channel of this type. Consumers would purchase an HDTV receiver to enable display of the advanced picture quality. The David Sarnoff Research Center's "ACTV-I" system operates in this fashion, as does the "MUSE-6" system proposed by NHK [Japan Broadcasting Corporation]. The Faroudja Research "SuperNTSC" approach is a variant of this approach, which actually incorporates no additional signals in the 6 MHz channel, but instead relies upon a carefully created, pristine NTSC signal which is enhanced locally in the receiver.

• A second option involves a standard, or at least compatible, NTSC channel augmented by an additional 3 or 6 MHz of spectrum

with the required HDTV information. The HDTV receiver would receive both channels, and combine the information to create the advanced picture. Pictures created in this way would presumably be of higher quality than those of the single-channel approach. The HDTV systems proposed by North American Philips and by the New York Institute of Technology use this approach, as does the Sarnoff Center's "ACTV-II". NHK's "MUSE-9" system also was designed in this fashion, but was recently withdrawn by NHK.

• Third is the simulcast approach, which leaves the current NTSC channel unmodified, and transmits a complete, non-compatible HDTV signal in a second, 6 MHz channel. Technically, this approach might conceivably provide the highest quality, since its transmission format would be unrelated to, and therefore unconstrained by, the limits of the original NTSC channel. A long term advantage to this architecture is that, after many years of operation, when the simulcast ATV signal becomes the dominant mode of television for viewers, the original NTSC channel could be discontinued, and the spectrum recovered for either additional HDTV channels, or perhaps as augmentation for some form of super-HDTV. The Zenith "Spectrum Compatible" HDTV system is a simulcast system, as is NHK's second proposal known as "Narrow MUSE". Philips Laboratories has recently announced a project to develop a simulcast system as well.

A fourth possibility, not currently being pursued actively, arises from the argument that digital compression and transmission techniques are progressing so rapidly that, by the year 2000, a fully digital HDTV signal of superior quality will be possible for transmission in a single, 6 MHz channel. At that time, the argument goes, the U.S. would see as tragically short-sighted its adoption of a fundamentally analog transmission standard in the early 1990's.

While an attractive idea, it exists only in concept at present, and the challenge to this concept is that it must rapidly develop enough substance to cause it's future implementation to be favored over other, more near-term advanced television concepts. This seems a difficult task, particularly given U.S. competitive desires in the face of European and Japanese plans

to move ahead in establishing national HDTV services in the mid-1990's.

Beside the technical merits of each of these individual system proposals, which are beyond the scope of this discussion, the basic channelization structures described above each involve widely different transitional scenarios. Broadcasters and cable operators would face vastly different time lines, economic incentives and costs, and consumer reactions, depending upon the approach taken. These have yet to be fully explored. It may be that excellent technical approaches that fall under the "wrong" spectrum architecture (as outlined above), could be discarded as unworkable for the industries involved.

On a simpler plane, there are some attributes of high definition television that, while easy to comprehend in concept, are nearly impossible to forecast with certainty. It is in the successful implementations of these attributes that the success of HDTV in the home may reside. A few of the most important of these are reviewed below.

Consumer Issues

Beginning with the intended consumer of high definition television, the home viewer, it is clear that prospects for success revolve around the desire for improved quality in home television and the value placed on that improvement by the viewer. Relatively little is known with confidence on this subject, and much must be learned before the transmission industries and the consumer electronics manufacturers will make the necessary commitments.

Today, viewers of NTSC pictures in the home tend to adjust their viewing distances from the screen so that their visual acuity minimizes the limitations of the 525-line pictures. That is, viewers arrange their receiver and furniture so that they watch television at a distance from the screen of six to nine times the picture's height. At these distances, the visible scanning

lines and the limited detail of the NTSC standard do not detract from the experience as they would if the receiver were viewed from closer distances. A high definition television screen of the same size, viewed from the same distances, would be of little value to its owner, since the finer scanning structure and additional detail would be imperceptible to the viewer.

HDTV, therefore, will require some combination of closer viewing and larger screens to be appreciated. Fundamental questions remain, though. Does the architecture of homes and their furniture allow for close viewing? Picture moving your furniture to half its current distance from your television. Is the room usable when the television is off? Alternately, assume you leave the furniture in place, but you install a receiver of twice the size. Do you have a wall big enough? Are you blocking daylight from the room? Will you accept the bulk of this huge receiver which may dominate the room's design?

A few years ago, these questions seemed trivial, but are now recognized as probably crucial to success of the medium. Consumer products have succeeded or failed on much less significant criteria.

Standards: Performance vs. Resources and Longevity

Somewhere in this equation of viewing distance and screen size is the question of actual displayed resolution. Among the ten advanced television transmission schemes currently being proposed for testing by the FCC Advisory Committee on Advanced Television, there are widely varying levels of displayed resolution. Theoretically at least, the approaches that utilize the widest channel bandwidth and that implement the most efficient information compression schemes, will have the superior pictures. In the end, how will spectrum cost and equipment complexity be traded off against picture quality? How good is good enough? And is good enough sufficient to sustain a chosen standard for ten, twenty or thirty years?

Broadcasters and cable operators are all working together through the FCC Advisory Committee to develop a common transmission standard that will provide maximum quality both over the air and via cable television plants. Both industries, however, are constrained to a basic structure of 6 MHz channels by either spectrum assignment or technical and economic factors. This is largely a function of the need to continue to serve the some 160 million NTSC receivers already in the marketplace, and to add HDTV services in an incremental fashion to a technical infrastructure oriented to an NTSC world. That NTSC world is generally acknowledged to have a remaining life measured in decades. Given these constraints, how will broadcasters and cable operators compete in quality with possible future direct-to-home satellite services, with unconstrained, free-form home video devices, and perhaps someday with fiber optic transmission?

Unlike broadcasters constrained by over the air spectrum considerations, cable television operators at least have the opportunity for upgrading their transmission plants to provide the additional bandwidth which may be required for HDTV services. With this in mind, an ideal technical solution to the standards question would involve an extensible signal format, which would provide improved quality with additions in channel bandwidth. Thus, while initial service over cable might begin with the universal broadcast/cable standard, future transmissions could extend the delivered quality, although always without disturbing service to viewers equipped to receive a signal lower in the hierarchy. Approaches such as this are well known to the computer industry, where application software must be structured to anticipate future generations of hardware, and new generations of software must retain compatibility with data files generated by previous versions of the application. Adopting an advanced television transmission standard without providing for its future competitiveness would be unwise. I believe this will come to be seen as a fundamental requirement in the current FCC inquiry into standards setting.

Costs for Producer, Distributor, Viewer

The set of technologies available to apply to high definition television -- image transducers, recorders, bandwidth compression, image display -- are fundamentally already in existence. Refinement and cost reduction are needed, but these will require only a few years to achieve, not decades. The proof is the existence of most of the fundamental high definition equipment in professional forms -- expensive, but in place. This includes professional cameras at a quarter of a million dollars, 40" monitors at $35,000, digital tape recorders at over $300,000, and laboratory prototypes of transmission systems created at the cost of millions of dollars.

This state of near-readiness, except for cost, is in sharp contrast with the gradual technical development that took place in the conventional television. The black and white standard was set in the early 1940's, and ran a full decade before the color standard was decided upon as a compatible enhancement to the monochrome standard. Even then, implementation of color television in production and transmission, both for broadcast and cable, waited until the mid-1960's. In the beginning, television was live for many years before professional video tape recording was invented, first in black and white, of course, and later in color. Decades passed before television cameras were built that could be held on the shoulder. The significance of this gradual development scenario was its comfortable fit with capital investment and depreciation cycles, always allowing reasonable recovery of equipment costs and reasonable profitability.

The same may not be possible in the new era of high definition television. One estimate of the capital investment required by a local television station runs nearly $40 million. Cable television plants, too, may require large investments. Very few cable systems have significant unused channel capacity that could be made available for high definition services, and HDTV service may require a level of quality in transmission well beyond that needed for NTSC.

Given the near-readiness of the technology (two to five years, perhaps), and the potentially large capital investments to be made over this short time period, where is the profit incentive to drive the conversion? If initial consumer HDTV receiver prices are three to eight times that of current NTSC receivers, which is where many estimates lie, is there hope of a rapid enough ramp-up in viewership to support the up-front costs for the distribution investment?

One recent presentation at an industry seminar reminded us that commercial broadcasters implemented both color television and stereo audio as enhancements to their existing service at their own expense, with no related ability to raise advertising rates. If advanced television evolves in a similar fashion, with very slow penetration rates in viewers' home, its greater cost base threatens even greater financial disruption. Industry efforts, then, need to develop implementation scenarios that are rational and supportable in an economic context.

The Case for Optimism

Like any review of critical factors, the preceding discussion may seem unduly pessimistic. The mood in the television industry is not pessimistic, in fact. There is concern over the time scale for HDTV implementation, but a growing belief that it is an inevitable and ultimately welcome part of the television industry.

On a personal level, individuals working toward implementation of HDTV systems are tremendously motivated, perhaps in large part by the excitement generated by the display of true high definition video. Properly demonstrated, the higher forms of advanced television easily convey a stunning sense of reality to the viewer. Some have wondered whether introduction of HDTV is fundamentally any more exciting than the introduction of color to a pre-existing black & white service. I suspect such questions come from those who have not seen true demonstrations of HDTV, at its original, studio level of quality. A viewing

should be a prerequisite to any serious work in this area, for it provides an intuitive understanding of the inevitable coming of high definition television.

The challenge before industry now is to bring it about sooner, not later, for the benefit of the public, but in a fashion that also serves industry and the economy in general.